

LINEAR MOTION COMPENSATOR

CROSS-REFERENCE TO RELATED PATENTS

[0001] Not applicable

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STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] Not applicable

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FIELD OF THE INVENTION

[0003] The present invention relates to operator interface devices, and particularly to a linear motion compensator for use with operator interface devices and electrical switching devices that have different linear operating strokes.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0004] The features of the invention will become more clearly understood from the following detailed description of the invention read together with the drawings in which:

20 Figure 1 illustrate a typical operator interface and contact module assembly of the prior art.

Figures 2A and 2B illustrate in cross-section the operator interface device of Figure 1.

Figures 3A, 3B and 3C illustrate in cross-section the normal operating conditions of the contact module of Figure 1.

25 Figures 4A and 4B illustrate in cross-section abnormal operating conditions of the contact block of Figure 3 when the operating stroke of the input device does not match the operating stroke of the contact module.

Figure 5 illustrates in exploded view, the operator interface device and output device of Figure 1 with a stroke compensator manufactured in accordance with the present invention.

Figures 6A and 6B, illustrate in a cutaway view, a stroke compensator of the

5 present invention installed between a typical operator interface device and a typical contact module.

Figure 7 illustrates an exploded view of one embodiment of a stroke compensator manufactured in accordance with the present invention.

Figures 8A and 8B illustrate the operation of the stroke compensator
10 embodiment of Figure 7.

Figure 9 illustrates an exploded view of a second embodiment of the stroke adapter manufactured in accordance with the present invention.

Before one embodiment of the invention is explained in detail, it is to be
15 understood that the invention is not limited in its application to the details of construction described herein or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various other ways.

Further, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

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DETAILED DESCRIPTION OF THE DRAWINGS

[0005] Figure 1 illustrates a typical configuration wherein an input device 10, such as an operator interface device, is assembled to an output device 14, such as an electrical switching device or contact module, in a control panel, switchboard or similar equipment 18. For operational simplicity, the input device 10, as shown in Figure 1, is a simple linear movement device, such as pushbutton operator. However, for the purpose of the present invention, the input device 10 can be any input device capable of producing a linear movement or displacement, such as a rotary or lever operator that incorporates a means, such as a cam, to translate the rotary or lever movement into a

linear movement. Also for operational simplicity, the output device **14**, as shown in Figure 1, is a simple contact module.

[0006] Figures 2A and 2B illustrate the two basic operating conditions of the input device **10**, of Figure 1. It is to be understood that more complex input devices, such as 5 rotary operators or multiple button operators, can have more than two operating conditions. The input device **10** typically includes a housing assembly **22** that can be constructed from one or more parts. The housing **22** substantially encloses and slidably supports an operating shaft **26**, having an input end **30** for receiving an external input and an output end **34** for transmitting the received external input to the output device 10 **14**. The housing assembly **22** defines an output end **38**, which includes means (not shown) for attaching to the output device **14**, and an aperture **42** through which a linear movement of the shaft **26** can be transferred to the output device **14**. The operating shaft **26** is normally biased to a first or normal position, as shown in Figure 2A, by means of a spring **46** or similar biasing device. In response to the external input, the 15 operating shaft **26** moves linearly within the housing assembly **22**, to a second or activated position adjacent the output end **38**, as shown in Figure 2B. When the input device **10** is in the second (activated) position, the output end **38** of the operating shaft **26** will have moved a particular linear distance or stroke **D₁** from its first position. Typically the stroke **D₁** is fixed by the internal construction of the input device **10** and 20 can not be altered. In a typical pushbutton device, the operating shaft **26** normally returns to its first position as soon as the external input is removed. However, some input devices **10** have a latching feature that is activated when the operating shaft **26** is moved into its second position. This latching feature maintains the operating shaft **26** in its second position until some particular manipulation of the input device **10** releases the 25 latch and allows the operating shaft **26** to return to its first position. Therefore, proper operation of such input devices **10** requires that the output end **34** of the operating shaft **26** be capable of moving the full particular linear distance **D₁**.

[0007] Figures 3A, 3B and 3C illustrate the three basic operating conditions of the output device **14** of Figure 1. The output device **14**, a contact module, includes a

housing assembly 50, which partially encloses and supports a linearly movable operating shaft 54, a first pair of stationary electrical contacts 58 and 62 and a second pair of stationary electrical contacts 66 and 70. The operating shaft 54 has an operating end 74, which extends outwardly from the housing assembly 50 through an aperture 78 defined in a first end 82 of the housing assembly 50. The first end 82 is configured for attachment to the operating end 38 of the input device 10, such that the operating end 74 of operating shaft 54 can engage the operating end 34 of the input device operating shaft 26, through the aperture 42. The operating shaft 54 supports an electrically conductive bridge 86 having a pair of bridging contacts 90 at each end. In the first 5 operating condition, the operating shaft 54 and its operating end 74 are normally biased to a first position, as shown in Figure 3A, by a spring 94, or similar biasing device. In this first position, the bridging contacts 90 engage the first pair of stationary contacts, 58 and 62, thereby completing an electrical path between the first pair of stationary contacts, 58 and 62, and defining them as normally closed (NC) contacts. The second 10 pair of stationary contacts, 66 and 70, are not engaged by the bridging contacts 90 and are therefore normally open (NO) contacts. The biasing means 94 provides sufficient force to slightly bow the bridge 86, thereby ensuring a good electrical connection between the bridging contacts 90 and first pair of stationary contacts 58 and 62. In the second operating condition, as shown in Figure 3B, the operating end 74 of operating 15 shaft 54 has been displaced from its first position, by a particular linear distance or stroke D_2 , to a second position adjacent to, or coincident with, the first end 82 of housing assembly 50. In this second position, the bridging contacts 90 have disengaged from the first pair of stationary contacts, 58 and 62, thereby opening the electrical path between them and have engaged the second pair of stationary contacts, 66 and 70, thereby completing an electrical path between them. The displacement of 20 the operating shaft 54 by the particular linear distance D_2 provides sufficient force to slightly bow the bridge 86, thereby ensuring a good electrical connection between the bridging contacts 90 and second pair of stationary contacts 66 and 70. In the third 25 operating condition, the operating end 74 of the operating shaft 54 has been displaced approximately one half of the stroke D_2 (shown as $D_2/2$). Therefore, neither of the first 30

or second pairs of stationary contacts, **58** and **62** or **66** and **70**, respectively, has a completed electrical path. This condition is not usually provided by simple pushbutton type input devices **10**, but is commonly supported by rotary operable input devices **10**. From the description of these operations it can be seen that the stroke **D₁** of the input device **10** must be equal, within operating tolerances, to the stroke **D₂** of the output device **14** for proper operation of both devices. This is generally not a problem when input devices **10** and output devices **14** are selected from the same product line, series or manufacturer. However, situations can arise when it is either necessary or desirable to mate an input device **10** from one product line, series or manufacturer with an output device **14** from another product line, series or manufacturer.

[0008] Figures 4A and 4B illustrate two of a number of situations which can occur when the operating parts of an input device **10** are not compatible with the operating parts of the output device **14** to which it will be attached. The illustrated conditions will be used in explaining the operation of the invention. As shown in Figures 4A and 4B, the operating end **34** of the input device operating shaft **26** is not properly positioned to engage the operating end **74** of the output device operating shaft **54**, when both devices are in the first or normal position and the stroke **D₁** of the input device operating shaft **26** is less than the stroke **D₂** of the output device operating shaft **54**. In this example, the operating end **34** of shaft **26** is positioned to close to the operating end **38** of housing assembly **22**. Therefore, the operating shaft **54** of the output device **14** is partially depressed and can not be moved to its first position (shown in dashed lines) by biasing spring **94**. This condition does not permit the bridging contacts **90** to engage the first pair of stationary contacts, **58** and **62**, when the input device **10** is in its first position. Further, since stroke **D₁** is less than stroke **D₂**, the input device **10** can not properly place the operating shaft **54** of the output device **14** in its second or activated position, as shown in Figure 4B. However, these conditions and others can be corrected by placing a stroke compensator, as disclosed herein, between the input device **10** and output device **14**.

[0009] Figure 5 illustrates an exploded view of the input device 10, output device 14 and one embodiment of a stroke compensator 98, manufactured in accordance with the present invention, intermediate the input and output devices, 10 and 14, respectively. The stroke compensator 98 includes a housing 102 which has a first end 5 106 adapted for connecting to the input device 10 and a second end 110 adapted for connecting to the output device 14.

[0010] Figures 6A and 6B, illustrate in cross-section, the assembled input device 10, stroke compensator 98 and output device 14 of Figure 5.

[0011] Figure 7 illustrates in exploded view the stroke compensator 98 of Figures 10 6A and 6B. The housing 102 substantially encloses and moveably supports at least one compensator cam 114 and at least one output plate 118. The compensator cam 114 is pivotably supported by the housing 102 and the output plate 118 is slidably supported by the housing 102. The compensator cam 114 includes a pivot pin 122, an 15 input round 126 and an output round 130. The pivot pin 122 is received in a pocket 134, intergrally formed in the housing 102, for pivotal movement therein. The input round 126 slidably engages the output end 34 of the operating shaft 26, as the input device 10 is operated. This slidable engagement between the output end 34 of the operating shaft 26 and the input round 126 causes the compensator cam 114 to pivot about its pivot pin 122, from an unactivated or first position as shown in Figure 8a to an 20 activated or second position as shown in Figure 8B. The output plate 118 has a flat surface 138, which is slidably engaged by the output round 130 of the compensator cam 114. The input and output rounds, 126 and 130, respectively, define a radius suitable for slidable engagement with the output end 34 of operating shaft 26 and the flat surface 138 of the output plate 118. The output plate 118 also includes two generally parallel 25 slides 142, each extending outwardly from, and being spaced apart by the flat surface 138. The slides 142 each have an outside surface 146, which defines an outwardly extending ridge 150. The ridges 150 are slidably received in slots 154 defined on opposed inside surfaces 158 of the housing 102. The ridges 150 maintain a generally parallel relationship between the flat surface 138 and the second end 110 of housing

102, as the output plate 118 moves linearly inside housing 102 in response to pivotal movement of the compensator cam 114 between its first and second positions. As the compensator cam 114 pivots about its pivot pin 122, the output round 130 causes the output plate 118 to slidably move toward the second end 110 of the housing 102. The 5 second end 110 of the housing 102 defines at least one aperture 162 for receiving the operating shaft 54 of the output device 14. An output surface 166 of the output plate 118 engages the operating end 74 of the operating shaft 54 of output device 14. As the compensator cam 114 is rotated between its first and second positions, in response to linear movement of the operating shaft 26 of input device 10 between its first and 10 second positions, the output plate 118 causes the operating shaft 54 of the output device 14 to be moved linearly between its first and second positions.

[0012] Referring now to Figures 8A and 8B, the operation of the compensator cam 114 will be explained in detail. The centers **A**, **B** and **C**, of the pivot pin 122, input round 126 and output round 130, respectively, of the compensator cam 114 form a 15 triangle 170, shown in dashed lines. The length of leg **ab** of triangle 170 is selected such that the input round 126 can move vertically (linearly) the known or measured stroke distance **D**₁ of the input device 10, without disengaging from the output end 34 of operating shaft 26, as the compensator cam 114 is rotated between its first and second positions. The length of leg **ac** of triangle 170 is selected such that the output round 20 130 can move vertically (linearly) the known or measured stroke distance **D**₂, required for properly operating the output device 14, without disengaging the flat surface 138 of output plate 118, as the compensator cam 114 is rotated between its first and second positions. Because of friction between sliding parts, the length of leg **ac** should also be selected such that the angle between leg **bc** and the flat surface 138 of operating plate 25 118 does not significantly approach 90° as the compensator cam 114 is rotated to its second position. This angle is related to the coefficient of friction of the materials of the compensator cam 114 and the operating plate 118, or other component with which the output round 130 is slidably engaged. Generally, when the angle between leg **bc** of triangle 170 and the flat surface 138 of the operating plate 118 exceeds 70°, the 30 possibility of a condition in which the compensator cam 114 does not return to its first

position increases. It is to be understood that limitations in the physical size of the housing 102 can restrict the placement of the pivot pockets 134 and the lengths of the legs **ab**, **ac** and **bc** of triangle 170. It is also to be understood that the three dimensional physical shape of the compensating cam 114 can be altered to 5 accommodate various configurations and restrictions of the housing 102 as long as a triangular configuration between the pivot pin 122, input round 126 and output round 130 is maintained. In some applications the operating plate 118 is not required, therefore the operating round 130 would directly engage the operating end 74 of the output device operating shaft 54 in generally the same manner as the input round 126 10 engages the operating end 34 of the input device operating shaft 26.

[0013] Figure 9 is an exploded view illustrating the stroke compensator housing 102 and a second embodiment of the invention. In this embodiment, a compensating screw 174, an input nut 178 and an output nut 182 are employed. For the purpose of this discussion the term "threads" will be defined as any combination of conventional 15 screw threads or grooves and ribs, ramps, nubs or similar projections, which can be configured to provide a spiral rotation between the compensating screw 174 and the input nut 178 or output nut 182. The compensating screw 174 has an input end 186, which threadably receives the input nut 178, an output end 190, which threadably receives the output nut 182 and a central flange 194. The central flange 194 is 20 captivated in a bearing pocket 198 formed in the housing 102. The bearing pocket 198 permits the compensating screw 174 to rotate within the housing 102, but prohibits linear movement. The input and output nuts, 178 and 182, respectively, each have ridges 202, which are slidably received in grooves 106 formed in the housing 102. The 25 ridges 202 permit linear movement within the housing 102, but prohibit rotational movement with respect to the housing 102.

[0014] The number of threads per inch or rate of twist of both the input end 186 and the output end 190 of the compensating screw 174 is such that a linear motion applied to either the input nut 178 or the output nut 182 will cause the compensating screw 174 to rotate easily about its axis. The rate of twist of the threads 210 of the input

end 186 and its associated input nut 178 are selected such that the compensating screw 174 will be rotated a particular angle θ when a linear motion equal to stroke D_1 of the input device 10 is applied to an input end 218 of the input nut 178. The rate of twist of the threads 214 of the output end 190 and its associated output nut 182 are selected

5 such that an output end 222 of the output nut 182 will move a linear distance equal to stroke D_2 of the output device 14 in response to the compensating screw 174 rotating the particular angle θ . The input end 218 of the input nut 178 is configured for engaging the output end 34 of the input device operating shaft 26 and the output end 222 of the output nut 182 is configured for engaging the input end 74 of the output device

10 operating shaft 54 through apertures 162 provided in the housing 102.